ABS ACTA BIOLOGICA SIBIRICA
A journal on the biodiversity of Siberia and the adjacent lands

Acta Biologica Sibirica 7: 425–439 (2021)
doi: 10.3897/abs.7.e71816
https://abs.pensoft.net

RESEARCH ARTICLE

A study on plant preferences of red panda (*Ailurus fulgens*) in the wild habitat: foundation for the conservation of the species

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Academic editor: R. Yakovlev | Received 19 July 2021 | Accepted 5 November 2021 | Published 8 December 2021

http://zoobank.org/F46132CA-D163-477C-A2C7-D698F0141D6B

Citation: Roka B, Jha AK, Chhetri DR (2021) A study on plant preferences of red panda (*Ailurus fulgens*) in the wild habitat: foundation for the conservation of the species. Acta Biologica Sibirica 7: 425–439. https://doi.org/10.3897/abs.7.e71816

Abstract

The red panda is a lesser carnivore that has adapted to the herbivore diet and is distributed in the Himalayan and Hengduan mountain ranges. The study conducted on red panda in Singalila National Park recorded the highest encounter of the species within the altitude of 2800 to 3200 meters in the broad leaf deciduous and broad leaf coniferous forest. 22.22% of direct sightings of red pandas occurred on plant species belonging to the family Fagaceae and were followed by the family Ericaceae (18.52%). The plant species mostly preferred by the red panda in Singalila National Park were *Lithocarpus pachyphyllus*, *Rhododendron arboreum*, *Abies densa*, and *Betulia utilis*. During all seasons, the dominant plants found in the red panda pellets were *Arundinaria maling* and *Arundinaria aristata*. The distribution of the red panda is influenced by the presence of the preferred plant species, therefore, through this studies effort has been made to document the plant species used by the red panda in the wild habitat.

Keywords

Conservation, plant preference, red panda, wild

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Introduction

Lesser panda commonly known as a red panda (*Ailurus fulgens*) is an endangered flagship carnivore that has adapted to the herbivore diet (Glatston 2010; Kandel 2015; Kumar 2016). It belongs to a monotypic family Ailuridae that resides in certain clusters within the temperate broadleaf and subalpine forests (Bista 2017). The red panda habitat ranges from Western Nepal to Sichuan Province in China. In the Indian Himalayas, the red panda is found in Arunachal Pradesh, Meghalaya, Sikkim, and West Bengal (Choudhury, 2001). The red panda is a shy and mostly solitary animal that gathers during mating season and prefers the bamboo understory, fallen logs, and shrubs (Dorji 2011; Panthi 2019). Although the actual number of red pandas in the wild is still not available, the global population is estimated to be 14,500 to 15,000 individuals (Xu 2018). The population of the red panda has declined rapidly in recent decades mainly due to anthropogenic impact and is placed in the endangered category of the IUCN red list (Glatston 2015). The distribution of red panda is profoundly influenced by the plant diversity and the vegetation cover of the habitat. Plants are the basis of ecosystem architecture and the change in plant diversity influences biomass production, decomposition, and nutrient cycling. Plants represent the foundation of the natural and changing ecosystem, maintain a sustainable food chain (Pelletier 2018) and constitute the vital components of wildlife habitat (Tuanmu et al. 2011; Liu; 2014) offering shelter to herbivore and carnivore species across many different ecosystems (Taylor et al. 2004; Nilsson 2005; Gillim 2007). They play a pivotal role in the diversification of organisms (Dres 2002), prevent natural disaster, and are involved in countless interspecific interactions (Farrell 1992). Various activities of the red panda are supported by the plant's presence and suitable habitat. Foraging activities are affected by the presence of edible plants and encourage animal migration to a particular habitat. Forests with a high preferred plant distribution are positively related to the abundance of red panda in their native habitat. However, anthropogenic activities have accelerated the extinction rate of global biodiversity around 100 to 1000 times more than the natural rate (Godefroid 2011). An increase in the human population in the surroundings of a protected area, relatively unsound socioeconomic conditions, and dependence on forest resources (Pradhan 2001) has caused degradation of forests, wildlife loss, and erosion in genetic diversity. Therefore, many recognize the present age as the Anthropocene age (Davies 2016), and the conservation scenario and habitat degradation have emerged as a major concern due to the rapid extinction of the species. Through this study, efforts have been made to investigate the distribution of red pandas and their preference for plants in wild habitat. This work is crucial in drawing up proper management strategies for afforestation, as it is essential for long-term conservation and population restocking in the wild.

Material and methods

Study area

The study was carried out in Singalila National Park, located in the North-West part of Darjeeling District; West Bengal. The elevation of the national park ranges from 2400 m to 3650 m above sea level and covers the core area of 78.6 sq km. The Singalila National Park has a boundary with Sikkim in the north and Nepal in the west. The mean temperature in the temperate zone of the park ranges between 7 and 17 °C in summer and between 1 and 10 °C in winter. In the subalpine zone, the mean summer temperature remains below 7 °C and in winter it remains below 1 °C (Roka 2020). Winter is extremely cold and extends from November to March. The hottest season is between April and June, just before the onset of the monsoon. Singalila National Park was declared a national park in 1992 and the red panda has become a significant protected species in the area.

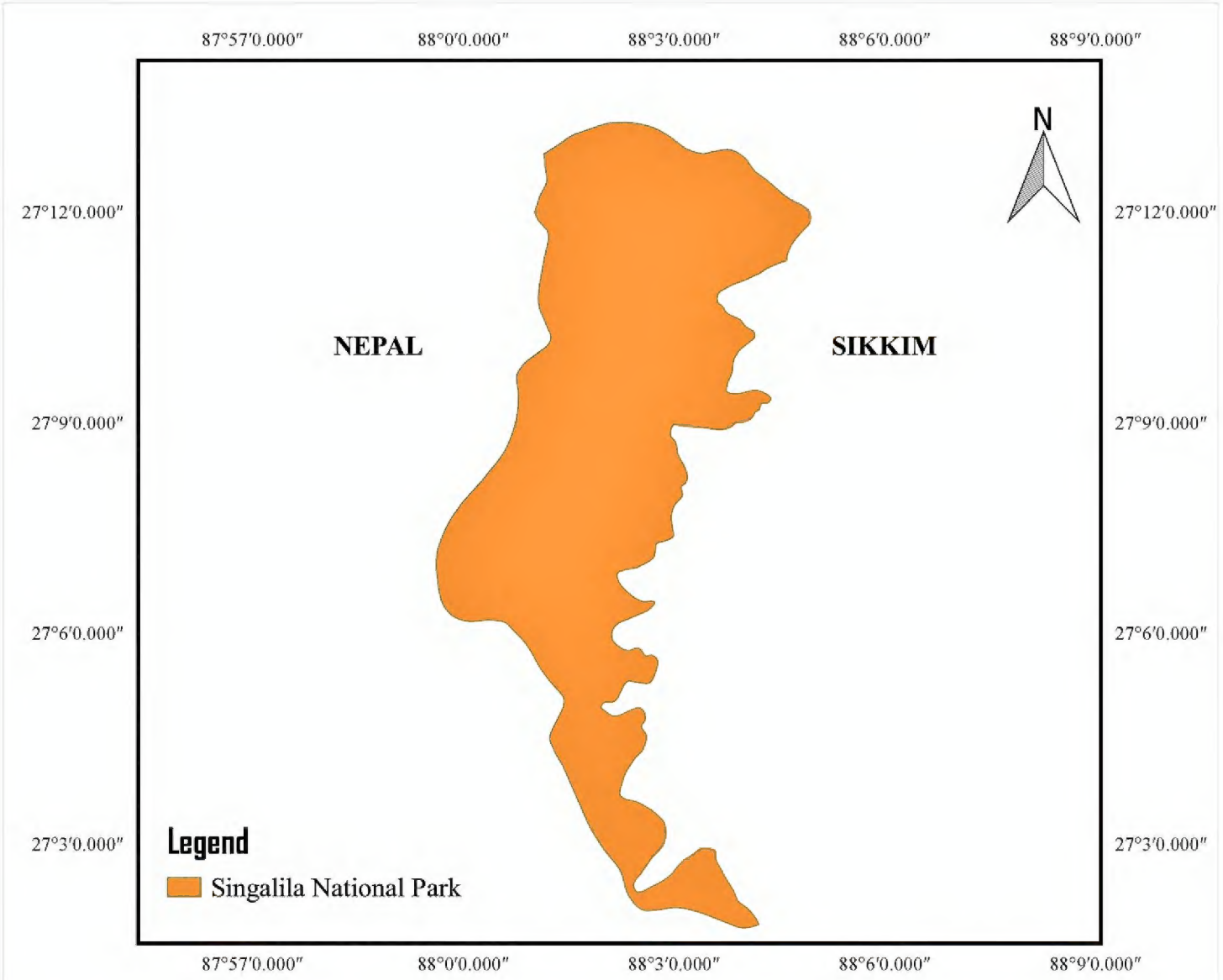

Figure 1. Singalila National Park, Darjeeling.

Methods

Various research articles, conference reports, book chapters, management plans, and thesis on red panda were collected while complying with first-hand information. A systematic review of the accessible literature on the red panda was carried out. Information on plant distributed in the red panda habitat, plant used and preferred by the red panda for nests building, sleeping, resting, defecating, and the edible plants were collected, and the taxonomic information of the species was verified with the latest nomenclature. Based on field knowledge, 20 existing paths and trails passing through different habitat types and altitudinal zones were carefully selected and followed four times in each season between 2012 and 2016. It was not possible to draw transects due to the rugged terrain and dense bamboo undergrowth in the park. Whenever direct or indirect evidence of red panda was encountered, habitat variability such as altitude, habitat type, tree species, shrub species, and bamboo species were quantified. Quadrats of 10×10 m were laid for measuring structure, composition, and a number of tree species. Bamboo and other shrub species were quantified in 3×3 m and for herbs 1×1 m quadrats were placed within 10×10 m quadrats in each major direction to collect information on ground cover. The data collected were analyzed for community parameters such as frequency, density, abundance, relative frequency, relative density, relative dominance, IVI as per Misra (1968) and Curtis and McIntosh (1950). Whenever pellets/scats were encountered, the states of the pellet group, substrates of defecation, and nearby sources of water were recorded. For food habit analysis, the year was divided into three seasons, viz., premonsoon (summer), monsoon, and postmonsoon (winter). Fresh pellet samples were collected season-wise and microhistological analysis of fecal pellets was performed following Stewart (1967), Todd and Hansen (1973), and Green (1987). The method involved two major steps: first, the reference material of the food plant species for the identification of epidermal and cellular characteristics of the species was prepared, and second, the micro histological examination of the fecal material was conducted to estimate the frequency of fragments of various plant species.

Results and discussion

During the study in Singalila National Park, a total of 31 direct sightings of red panda occurred at various seasons. As the red panda is a solitary animal, in most cases a single animal was sighted except for the breeding period. All the sighted animals were adult in size and active (Fig. 2). The sightings were for a very short period, and in maximum cases, the species were found resting at the top of the trees. 54.84% (n=17) of the red panda sightings occurred in the broad leaf deciduous forest within the altitudinal of 2801 m to 3000 m, 41.93% (n=13) of the sightings occurred in the broad leaf coniferous forest within the altitude of 3001 m to 3200 m and 3.22 % (n=1) occurred in an oak forest with the altitude of 2400 m to 2600 m. Red pandas

were sighted on 16 plant species in Singalila National Park (Table 1). Plants belonging to the family Fagaceae were used maximum to rest and sleep during the day and were followed by Ericaceae, Pinaceae, and Araliaceae (Fig. 3) by the red panda. Four red pandas were sighted on the ground while feeding on the bamboo leaves. The encounter rate of the red panda has been positively associated with the greater canopy forest, less disturbed area, high density of edible plants, and water.

Figure 2. Red panda in Singalila National Park.

Table 1. Red panda sighted on the plant species

Sl. No	Plant	Family	Local name	Sighting of red panda
1	*Abies densa* Griffith	Pinaceae	Gobray	14.81% (n=4)
2	*Lithocarpus pachyphyllus* (Kurz) Rehder	Fagaceae	Bantay	14.18% (n=4)
3	*Rhododendron arboreum* var. *cinnamomeum* (Wallich ex G.Don) Lindley	Ericaceae	Lali Gurash	11.11% (n=3)
4	*Castanopsis tribuloides* (Sm.) A.DC.	Fagaceae	Musuray Katus	7.4% (n=2)

Sl. No	Plant	Family	Local name	Sighting of red panda
5	*Schefflera rhododendrifolia* (Griff.) Frodin	Araliaceae	Bhalu Chinday	7.4% (n=2)
6	*Betula utilis* D.Don	Betulaceae	Bhujapat	7.4% (n=2)
7	*Rhododendron griffithianum* Wight	Ericaceae	Seto Chimmal	3.7 % (n=1)
8	*Ilex fragilis* Hooker	Aquifoliaceae	Lishey	3.7 % (n=1)
9	*Eurya acuminata* DC.	Pentaphylacaceae	Ghinjani	3.7 % (n=1)
10	*Rhododendron falconeri* Hooker f.	Ericaceae	Kurlingo	3.7 % (n=1)
11	*Symplocos lucida* (Thunb.) Siebold & Zucc.	Symplocaceae	Kholmay	3.7 % (n=1)
12	*Vitex negundo* L.	Verbenaceae	Pachpatey	3.7 % (n=1)
13	*Magnolia campbellii* Hooker f. and Thomson	Magnoliaceae	Ghogay chap	3.7 % (n=1)
14	*Acer campbelli* Hooker f and Thomson ex Hiern	Sapindaceae	Kapasi	3.7 % (n=1)
15	*Merrilliopanax alpinus* (Clarke) C.B. Shang	Araliaceae	Phutta	3.7 % (n=1)
16	*Litsea sericea* (Wall. ex Nees) Hook. f.	Lauraceae	Lekh Siltimbur	3.7 % (n=1)

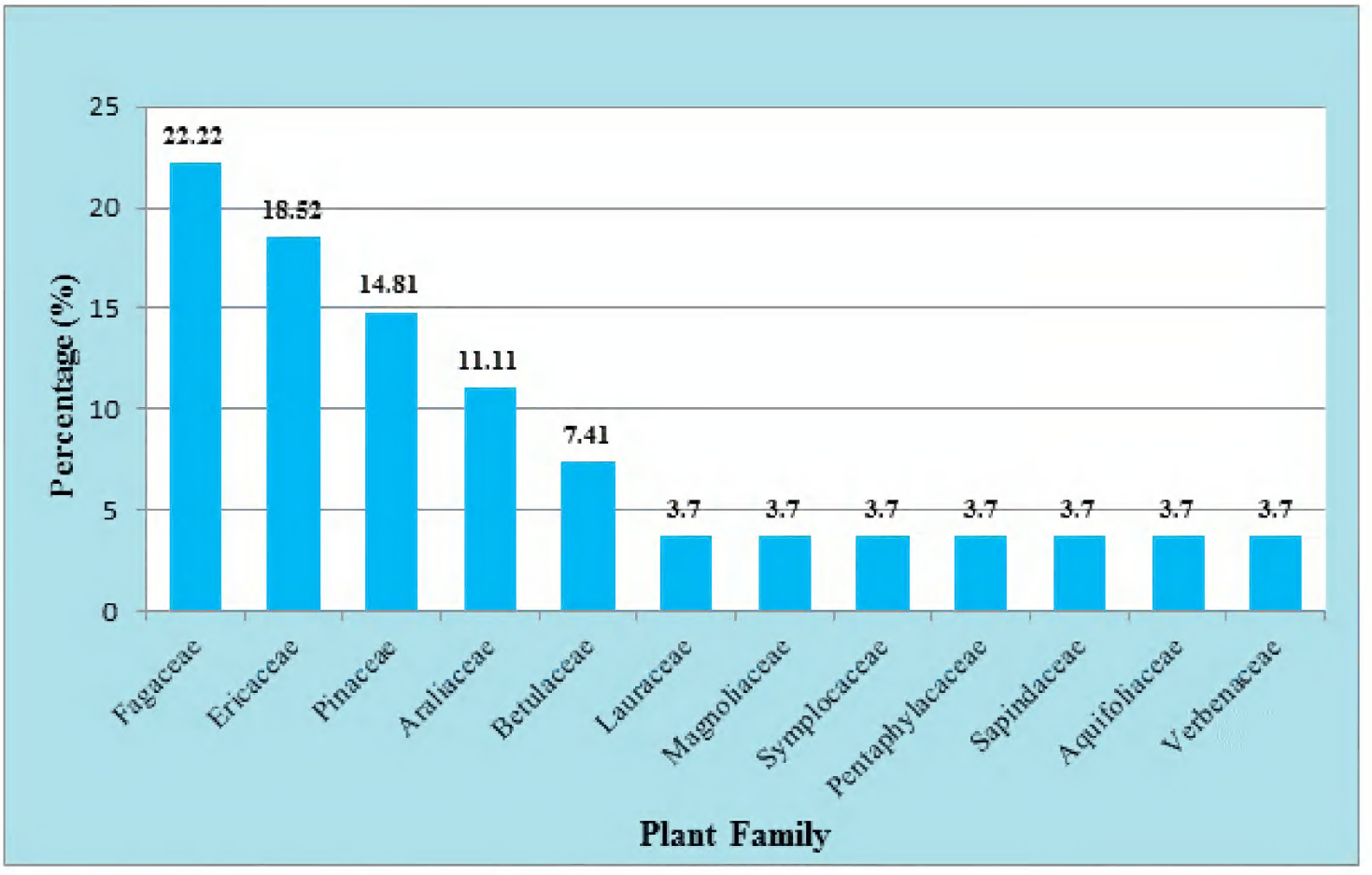

Figure 3. Direct sighting of red panda.

Pellet/scat gives a good indication of the presence and habitat suitability of the species. In Singalila National Park, red panda pellets/scats were sighted on 23 different plant species. The encounters of pellets/scats were highest in the plant species belonging to the Fagaceae, Ericaceae, and Lauraceae families (Table 2). The frequency of pellet and direct sighting was highest within 100 m of water.

Table 2. Red panda scats on the plant species

Sl. No	Plant	Family	Local name	Sighting of scats
1	*Lithocarpus pachyphyllus* (Kurz) Rehder	Fagaceae	Bantay	22.48% (n=58)
2	*Rhododendron arboreum* var. *cinnamomeum* (Wallich ex G.Don) Lindley	Ericaceae	Lali gurash	12.4% (n=32)
3	*Sorbus cuspidata* (Spach) Hedl.	Rosaceae	Tenga	6.59% (n=17)
4	*Magnolia campbellii* Hooker f. and Thomson	Magnoliaceae	Ghogey chap	6.59% (n=17)
5	*Rhododendron griffithianum* Wight	Ericaceae	Seto chimmal	6.2% (n=16)
6	*Castanopsis tribuloides* (Sm.) A.DC.	Fagaceae	Musuray Katus	6.2% (n=16)
7	*Betula utilis* D.Don	Betulaceae	Bhujapat	5.81 % (n=15)
8	*Merrilliopanax alpinus* (Clarke) C.B. Shang	Araliaceae	Phutta	5.81 % (n=15)
9	*Litsea sericea* (Wall. ex Nees) Hook. f.	Lauraceae	Lekh Siltimbur	5.81% (n=15)
10	*Ilex fragilis* Hooker	Aquifoliaceae	Lishey	4.26 % (n=11)
11	*Litsea elongata* (Nees) Hooker f.	Lauraceae	Pahili	3.88 % (n=10)
12	*Vitex negundo* L.	Verbenaceae	Pachpatey	3.49 % (n=9)
13	*Rhododendron falconeri* Hooker f.	Ericaceae	Kurlingo	3.1 % (n=8)
14	*Tsuga dumosa* (D.Don) Eichler	Pinaceae	Tingray	1.55 % (n=4)
15	*Acer campbelli* Hooker f and Thomson ex Hiern	Sapindaceae	Kapasi	1.55 % (n=4)
16	*Pieris formosa* Wall	Ericaceae	Balu	0.77 % (n=2)
17	*Symplocos lucida* (Thunb.) Siebold & Zucc.	Symplocaceae	Kolmay	0.77 % (n=2)
18	*Taxus baccata* L.	Taxaceae	Dinghray	0.77 % (n=2)
19	*Symplocos dryophila* Clarke	Symplocaceae	Kharanay	0.39 % (n=1)
20	*Schefflera rhododendrifolia* (Griff.) Frodin	Araliaceae	Bhalu Chinday	0.39 % (n=1)
21	*Abies densa* Griffith	Pinaceae	Gobray	0.39 % (n=1)
22	*Eurya acuminata* DC.	Pentaphylacaceae	Ghinjani	0.39 % (n=1)
23	*Machilus edulis* King ex Hook.f.	Lauraceae	Kawlo	0.39 % (n=1)

Phytosociological study

Quantification of the diversity of trees is essential to understand the forest dynamics as it influences the energy flow, nutrient cycle, and provides suitable habitat for animals. It is also important to study understory tree species, as it shows the species composition of the communities (Sagar, 2008). Phytosociological analysis conducted in the red panda and its pellet encountered area revealed a total of 40 tree species belonging to 26 genera and 18 families (Table 3). The family with the highest number of species was Ericaceae with 11 species that were followed by Betulaceae, Fagaceae, Lauraceae, and Sapindaceae each having 3 species, while the family Aralaceae, Pinaceae, Rosaceae, and Symplocaceae had 2 species each. The most dominant species in the study area was *Lithocarpus pachyphyllus* (47.86), followed by *Abies densa* (33.01) and *Rhododendron arboreum* (22.6). The Shannon-Wiener diversity index (**H'**) was 3.344 and the species richness (**D**) was 1.098. The concentration of dominance (**CD**) and the evenness for the tree species (**J'**) were estimated as 0.0448 and 0.907, respectively (Fig. 4).

A total number of 19 shrub species belonging to 11 families were recorded. The family with the highest number of shrubs in the area was Rosaceae with 4 species. The shrubs with the highest density in the area were *Arundinaria aristata*, *Arundinaria maling*, *Berberis aristata*, *Polygonum molle*, *Rhododendron lepidotum*, *Rubus ellipticus*, *Rubus lineatus*, and *Viburnum continifolium*. Similarly, *Smilax ovalifolia*, *Rubus buergeri*, *Theropogon pallidus*, and *Clematis montana* were the herb species with the highest density in the area. *Actinidia callosa*, *Rubia cordifolia*, and *Schisandra grandiflora* were a few climber species recorded in the area.

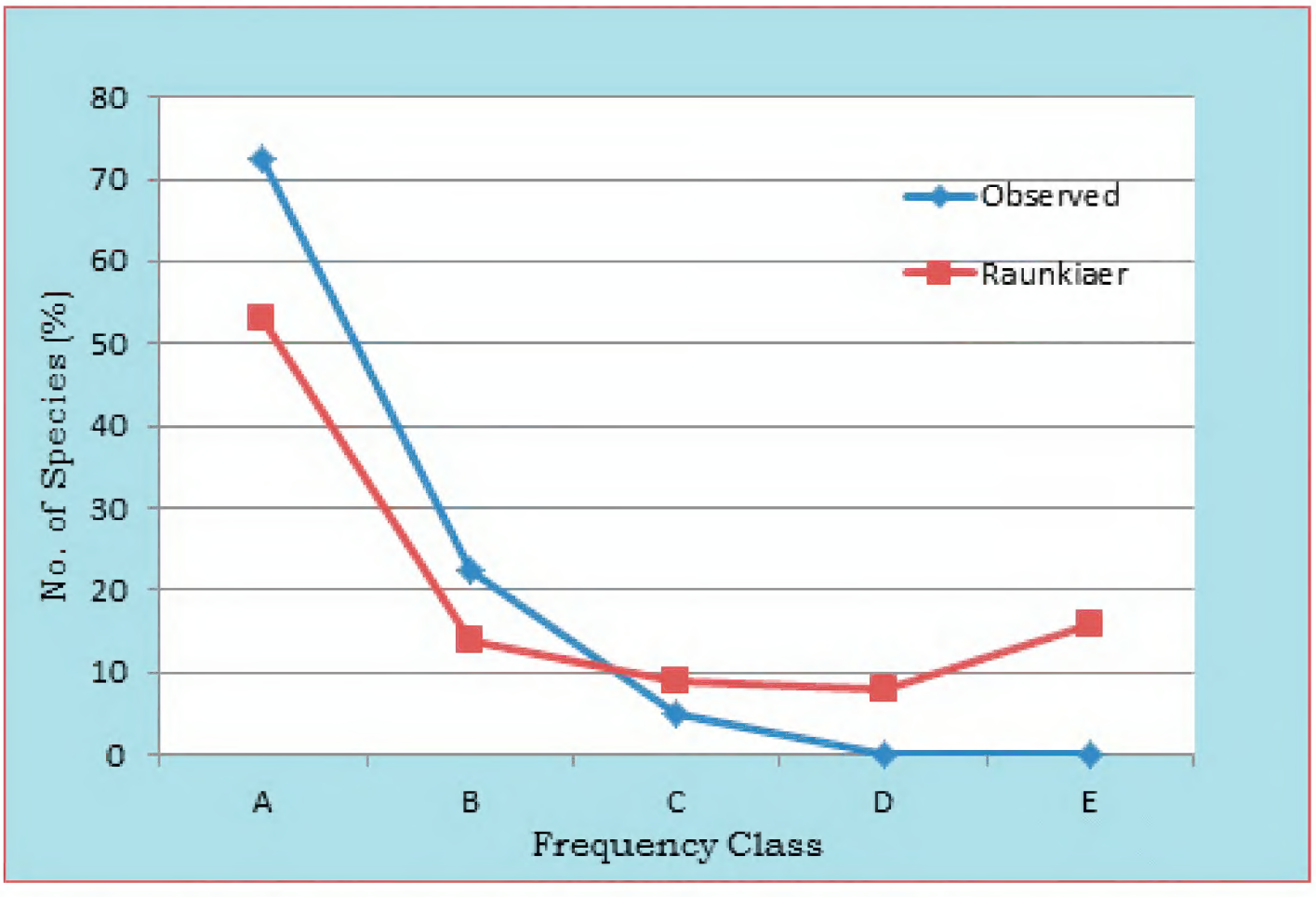

Figure 4. Comparison of Observed Frequency with Raunkiaer's Frequency Distribution.

Table 3. Trees in the red panda habitat

Scientific name	Family	Local name	F	D	A	RF	RD	RA	RDm	IVI
Abies densa Griffith	Pinaceae	Gobray	20.19	89.42	4.43	3.52	7.01	4.97	22.48	33.01
Acer campbelli Hooker f and Thomson ex Hiern	Sapindaceae	Kapasi	19.23	28.85	1.5	3.36	2.26	1.69	0.681	6.3
Acer caudatum Wallich	Sapindaceae	Kapasi	1.92	2.88	1.5	0.34	0.23	1.69	0.007	0.57
Acer pectinatum Wallich ex Nicholson	Sapindaceae	Lekh Kapasi	0.96	1.92	2	0.17	0.15	2.25	0.003	0.32
Alnus nepalensis D.Don	Betulaceae	Utish	4.81	9.62	2	0.84	0.75	2.25	0.126	1.72
Betula alnoides Buch.-Ham. ex D.Don	Betulaceae	Saur	9.62	18.27	1.9	1.68	1.43	2.13	1.115	4.22
Betula utilis D.Don	Betulaceae	Bhujapat	15.38	33.65	2.19	2.68	2.64	2.46	0.472	5.79
Castanopsis hystrix Hook. f. & Thomson ex A. DC.	Fagaceae	Katus	0.96	0.96	1	0.17	0.08	1.12	0.002	0.25
Castanopsis tribuloides (Sm.) A.DC.	Fagaceae	Musuray Katus	12.5	19.23	1.54	2.18	1.51	1.73	0.514	4.2
Daphniphyllum himalense (Bentham) Mueller Argoviensis	Daphiphyllaceae	Lekh Chandan	9.62	29.81	3.1	1.68	2.34	3.48	0.214	4.23
Endospermum chinense Benth.	Euphorbiaceae	Seti Kath	8.65	13.46	1.56	1.51	1.06	1.75	0.0215	2.59
Eurya acuminata DC.	Pentaphylacaceae	Ghinjani	8.65	11.54	1.33	1.51	0.9	1.5	0.054	2.47
Ilex fragilis Hooker	Aquifoliaceae	Lishey	24.04	42.31	1.76	4.19	3.32	1.98	1.104	8.61
Lithocarpus pachyphyllus (Kurz) Rehder	Fagaceae	Bantay	45.19	118.27	2.62	7.89	9.27	2.94	30.707	47.86
Litsea elongata (Nees) Hooker f.	Lauraceae	Pahili	9.62	25	2.6	1.68	1.96	2.92	0.273	3.91
Litsea sericea (Wall. ex Nees) Hook. f.	Lauraceae	Lekh Siltimbur	23.08	33.65	1.46	4.03	2.64	1.64	1.076	7.74

Scientific name	Family	Local name	F	D	A	RF	RD	RA	RDm	IVI
Machilus edulis King ex Hook.f.	Lauraceae	Kawlo	5.77	14.42	2.5	1.01	1.13	2.81	0.257	2.39
Magnolia campbellii Hooker f. and Thomson	Magnoliaceae	Ghogay Chap	20.19	23.08	1.14	3.52	1.81	1.28	0.932	6.26
Meliosma dilleniifolia (Wall. ex Wight & Arn.) Walp.	Sabiaceae	Lekh Gagun	10.58	12.5	1.18	1.85	0.98	1.33	0.079	2.9
Merrilliopanax alpinus (Clarke) C.B. Shang	Araliaceae	Phutta	16.35	18.27	1.12	2.85	1.43	1.26	0.098	4.38
Osmanthus suavis King ex C.B.Clarke	Oleaceae	Sirlingay	21.15	49.04	2.32	3.69	3.84	2.6	1.33	8.86
Prunus undulata Buch.-Ham. ex D.Don	Rosaceae	Arupatay	6.73	8.65	1.29	1.17	0.68	1.44	0.144	2
Pieris formosa Wall	Ericaceae	Balu	12.5	31.73	2.54	2.18	2.49	2.85	0.105	4.77
Quercus lamellosa Smith	Fagaceae	Thulo Phalat	14.42	30.77	2.13	2.52	2.41	2.41	2.909	7.84
Quercus lineata Blume	Fagaceae	Sanu Phalat	8.65	15.39	1.78	1.51	1.21	2	0.799	3.51
Rhododendron arboreum Smith	Ericaceae	Lali Ghurash	41.35	97.12	2.35	7.21	7.61	2.64	7.772	22.6
Rhododendron arboreum var. cinnamomeum (Wallich ex G. Don) Lindley	Ericaceae	Lali Ghurash	25	77.89	3.12	4.36	6.1	3.5	7.224	17.69
Rhododendron barbatum Wallich ex G. Don	Ericaceae	Rato Chimal	4.81	25	5.2	0.84	1.96	5.84	0.304	3.1
Rhododendron falconeri Hooker f.	Ericaceae	Kurlingo	8.65	28.85	3.33	1.51	2.26	3.74	0.252	4.02
Rhododendron grande Wight	Ericaceae	Kurlingo	9.62	26.92	2.8	1.68	2.11	3.15	0.239	4.03
Rhododendron griffithianum Wight	Ericaceae	Seto Chimmal	32.69	96.15	2.94	5.7	7.54	3.3	2.429	15.67
Rhododendron hodgsonii Hooker f	Ericaceae	Gulabi Chimal	4.81	25.96	5.4	0.84	2.03	6.07	1.695	4.57

Scientific name	Family	Local name	F	D	A	RF	RD	RA	RDm	IVI
Rhododendron cinnabarinum Hook.f.	Ericaceae	Sano chimal	1.92	1.92	1	0.34	0.15	1.12	0.001	0.49
Schefflera rhododendrifolia (Griff.) Frodin	Araliaceae	Bhalu Chinday	2.88	11.54	4	0.5	0.9	4.49	0.117	1.52
Sorbus cuspidata (Spach) Hedl.	Rosaceae	Tenga	18.27	26.92	1.47	3.19	2.11	1.66	1.392	6.69
Symplocos dryophila Clarke	Symplo-caceae	Kharanay	35.58	74.04	2.08	6.21	5.8	2.34	4.727	16.74
Symplocos lucida (Thunb.) Siebold & Zucc.	Symplo-caceae	Kolmay	25.96	48.08	1.85	4.53	3.77	2.08	2.195	10.49
Taxus baccata L.	Taxaceae	Dinghray	5.77	6.73	1.17	1.01	0.53	1.31	0.092	1.63
Tsuga dumosa (D.Don) Eichler	Pinaceae	Tinghray/ Hamlok	17.31	29.81	1.72	3.02	2.34	1.93	5.592	10.95
Vitex negundo L.	Verbenaceae	Pach patay	7.69	16.35	2.13	1.34	1.28	2.39	0.488	3.11

Notes: F = frequency, D = density, A = abundance, RF = relative frequency, RD = relative density, RA = relative abundance, RDm = relative dominance, IVI = importance value index.

Food habit

During the study, pellet samples were collected in the premonsoon (summer), monsoon, and postmonsoon (winter) seasons. The beginning of summer and the arrival of the monsoon marked drastic changes in plant phenology and vegetative growth. Most plant species attain maximum biomass during the monsoon. This is the season in which the highest diversity of food plants occurs and the late monsoon has the highest flowering and fruiting in the area. The senescence of the vegetation sets in winter, limiting the availability of food for the species. Therefore, the pellets were collected in various seasons. *Arundinaria maling* and *Arundinaria aristata*, two bamboo species were the main diet of red panda during all seasons and were highest in pellets. Both leaves and shoots were found mainly in the pellets. *Rosa sericea* and *Rubus* sp were found only in the summer season and *Sorbus cuspidata* and *Actinidia callosa* were found in the post-monsoon season in the pellet samples. The leaves of *Rhododendron arboreum*, *Polygonum molle*, and *Merrilliopanax alpinus* were also present in the pellets during the study. This study supports the research conducted by Yonzon (1989), as the pellet analysis showed that 68.4 % of the red panda diet constitutes bamboo along with the *Sorbus cuspidata* and *Sorbus microphylla*. Wei (1999) in his study also highlighted that in China and India, bamboos are the main food resource of the species. A previous study conducted in Singalila National Park in the 1990s by Pradhan (2001) stated that *A. maling* and *A. aristata* were the main

diets of the red panda. Panthi (2012) reported that *Arundinaria* spp. comprises the largest (81.7%) portion of the red panda diet. *Acer* spp. (4.5%), *Q. semicarpifolia* (3.3%), *Berberis* spp. (2.1%), and lichens (2%) were other plants present in the red panda pellets. Therefore, various studies on red pandas throughout their distribution range support that the distribution of red panda in the wild depends mainly on the presence of dense bamboo understory and edible fruits and plants.

Discussion

Anthropogenic activities such as the collection of fodder, cattle grazing, land use changes, and dependence of humans on the forest product influence the distribution and abundance of the plant (Sharma 2010). Natural disasters such as landslides, floods, the presence of invasive species, and bamboo flowering play a pivotal role in the change in forest vegetation and the population of a species. The red panda is a unique carnivore that has adapted to the herbivore diet and depends mainly on plants for its diet (Roka 2020). The habitat of the red panda in Singalila National Park was covered with dense bamboo understory and mainly determined the abundance and distribution of the red panda. Bamboo being the main food of the red panda, its loss may be a major threat to the survival of the species. It is important to understand the food habits of a species, in terms of food preference and availability, for the evaluation and management of its habitat (Norton 1984). Riney (1982) has discussed the relevance of food habit studies in making management decisions. Forage quality has been found to be an important determinant of herbivore habitat use. In Singalila National Park, the red panda feed mainly on *Arundinaria maling*, *Arundinaria aristata*, *Sorbus cuspidata*, *Actinidia callosa*, *Rosa sericea*, *Polygonum molle*, and *Rubus* sp. The leaves and shoots of *Arundinaria maling* and *Arundinaria aristata* constitute the main diet of the red panda. The presence of these species supported the distribution of the red panda. Tree species with high canopy cover were preferred for resting, sleeping, and nest building by the red panda in the study area. Tall trees with longer branches provide easy foraging opportunities and also avoid predation (Bista 2019; Dorji 2011). In all cases, red pandas were encountered within 100 meters of the water source. Conservation efforts initiated by the government, researchers, conservationists, and frontline staff have focused mainly on endangered endemic fauna. Comparatively less emphasis has been given to the conservation of plant species. The plant associated with the red panda plays a significant role in mitigating the threat to the survival of the species. A large part of the red panda habitat is under severe threat due to anthropogenic impact and climate change (Thapa 2018). Restoration of habitat in the buffer zone, transboundary, and wildlife corridors by afforestation of plants associated with the red panda is essential for the long-term management of the species in the wild.

Acknowledgements

We sincerely thank Ms. Upashna Rai, Padmaja Naidu Himalayan Zoological Park, for her support and guidance during the study. The authors are grateful to Central Zoo Authority, West Bengal Zoo Authority, and Padmaja Naidu Himalayan Zoological Park for providing various supports during the study of red panda (*Ailurus fulgens*) in ex situ and in situ facilities for conservation breeding. We express our gratitude to the West Bengal Forest Department for permission to conduct research work in Singalila National Park, Darjeeling, and the forest officials of Singalila National Park for their continuous help in the field.

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